Identification and Management of Injuries Associated with Femoral Shaft Fracture

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ABSTRACT

Femoral shaft fractures are common injuries typically due to high-energy trauma. Injuries associated with femoral shaft fractures include ipsilateral femoral neck fractures, ipsilateral distal femur fractures, ipsilateral patella fractures, ipsilateral tibial shaft fractures, ipsilateral knee ligament injuries, acetabular and pelvis fractures, and small bone fractures. These injuries can go unnoticed, and it is important to recognize and treat these injuries accordingly.

Keywords: Femur Shaft Fracture, Femur Fractures, Associated Injuries, Fractures, High-Energy Trauma

INTRODUCTION

Femoral shaft fractures (FSF) can occur in isolation or in combination with other injuries. The associated injuries may not be initially recognized. Delayed diagnosis of associated injuries often results in suboptimal and occasionally disastrous outcomes. Even if recognized early, associated injuries can complicate treatment and outcomes in patients with FSF. This current concepts review article identifies injuries associated with FSF, recommends protocols to identify associated injuries in a timely fashion, and outlines treatment recommendations when associated injuries exist. The most common injuries associated with FSF are listed in Table 1. These injuries are often not diagnosed initially for a variety of reasons (Table 2). The associated injury may preclude standard treatment of isolated FSF. The failure to initially diagnose associated injuries may increase the risk of complications.

ASSOCIATED FEMORAL NECK FRACTURE

FSF, combined with femoral neck fractures (FNF), occur most commonly in high-energy trauma such as motor-vehicle accidents (MVA) or motorcycle accidents. FSF combined with FNF typically occur in the younger population.[1] The latest literature has shown that 2.5 to 9% of FSF have an associated ipsilateral FNF.[2] The presentation is usually a comminuted middle third of the diaphysis FSF with 15 to 33% of the cases being an open fracture.[2] The associated FNF in 60% of the cases

Table 1. *Common injuries associated with femoral shaft fractures*

Femoral Neck Fracture
Distal Femur Fracture
Ipsilateral Knee Ligament Injury
Ipsilateral Tibia Shaft Fractures
Ipsilateral Patella Fractures
Acetabular/Pelvis Fractures
Small Bone Fractures

Table 2. *Reasons associated injuries are initially missed*

Reason	Why Associated Injury is Missed
Distracting obvious injury (ie, femur shaft fracture)	No radiographs taken of associated injury
Satisfaction of search	Radiograph taken and associated injury exists
Radiologically occult	Radiograph taken but associated injury exists but not visible
Symptomatically occult	Patient doesn't complain

is a vertical, basilar, and minimally displaced fracture.[2] This is most likely due to the axial compression mechanism on the femur at the time of injury. Recent literature has shown between 6 to 22% missed diagnosis of the FNF on the initial assessment.[2]

FNF can result in avascular necrosis (AVN) of the femoral head. The risk of AVN after FNF is increased with delay in diagnosis and treatment. The risk of AVN, nonunion, and malunion is increased by suboptimal reduction and fixation.[1] These complications are much more common in the displaced FNF, and they are difficult to treat in the younger population. FNF are usually caused by trauma but can be iatrogenic during antegrade femoral nailing, especially with an anterior starting point.[3] It is critical to diagnose the FNF before placing the intramedullary nail (IMN), so one can choose the correct operative fixation and be mindful not to displace the FNF. Tornetta et al[4] recommends obtaining anteroposterior (AP) radiographs of the internal rotation of the hip, a thin cut (2 mm) high-resolution computed tomography scan, and normal preoperative

radiographs of the femur.[4] Additionally, they recommend intraoperative fluoroscopic lateral evaluation of the hip prior to operative fixation, and intraoperative AP and lateral radiographs of the hip prior to awakening the patient.[4] Rogers et al[5] added a preoperative rapid limited sequence (ie, T1 and STIR sequences on the coronal view only) magnetic resonance imaging (MRI) protocol if the thin cut (2 mm), high-resolution CT scan was negative. They found an additional 12% of their patients with high-energy FSF had FNF that was not recognized on the radiographs or thin cut, high-resolution CT imaging.[5] The MRI took less than 10 minutes to perform and, in the majority of cases, was conducive to a multi-trauma patient (Table 3).[5]

Treatment of Associated FNF

The FNF takes priority. Most of the time, FNF is fixed prior to fixing the FSF, and it should be at least provisionally fixed before addressing the FSF. In their study from three trauma centers, Ostrum et al[6] showed good outcomes from treating the FNF with either a compression hip screw (CHS), short side plate and anti-rotational screw, or cannulated screws and retrograde IMN. There were 40 patients treated with CHS, short side plate, and anti-rotational screw, and 52 patients treated with cannulated screws. They saw no difference in femoral neck union or alignment when comparing cannulated screws to sliding hip screw. Their union rate was 98% (90 of 92 fractures) for the FNF, and 91.3% (84 of 92 fractures) for the FSF.[6] If the FNF is recognized after antegrade nailing and is non-displaced, then the "Miss-a-nail technique" can be considered. This technique uses lag screws across FNF, around the nail. Another option is using a "reconstruction" nail with proximal locking screws into the femoral head and across the FNF. If this method is chosen, then extra screws outside the nail can be considered to give more stability and fixation to the FNF.

DISTAL FEMUR

It is important to evaluate the distal femur for articular disruption either from extension of the FSF or a complete separate fracture. Literature shows a few cases of a coronal plane fracture of the femoral condyles (Hoffa Fracture) with FSF.[7] It is imperative to get radiographs of the joints above and below the FSF to rule out associated fractures. If radiographs look suspicious then order a CT scan.

Treatment of Distal Femur Fractures

Distal femur fractures with FSF can be treated various ways depending on the distal femur fracture type. When there is a distal intra-articular femur fracture associated with a FSF, then a retrograde nail with lag screws in the large articular fragments is an effective strategy. When the shaft fracture is in the distal one-third of the shaft, it is possible to treat this combination with a long lateral side plate and screws. If there is a Hoffa fracture of medial or lateral femoral condyle associated with FSF, then appropriate treatment is comprised of antegrade or retrograde nailing with anterior to posterior, or posterior to anterior, lag screws across coronal plane fracture.

Table 3. *Protocol for Diagnosing femoral neck fractures (FNF)[4,5]*

1	For acute, high-energy femoral shaft fractures (FSF): obtain femur radiographs and an anteroposterior (AP) internal rotation hip radiograph preoperatively.
2	Obtain thin cut (2 mm), high-resolution computed tomography (CT) scan of the ipsilateral femoral neck of the FSF or reformat the initial trauma chest, abdomen, and pelvis CT scan to a thin cut.
3	If radiographs and thin cut (2 mm), high-resolution CT scan is negative, one may consider ordering a rapid limited sequence (T1 and STIR on coronal view only) magnetic resonance imaging of the ipsilateral hip.
4	Intraoperative fluoroscopic lateral evaluation of the hip prior to operative fixation of the FSF.
5	If FNF is not seen on fluoroscopy while performing operative fixation of FSF, then obtain AP and lateral radiographs of the hip in the operating room prior to awakening the patient.
6	At follow-up visit, obtain femur radiographs and ask about hip pain. If hip pain present, then obtain AP and lateral radiographs of the ipsilateral hip.

PATELLA FRACTURE

Patella fractures account for about 1% of all fractures,[8] and can occur in combination with FSF. To fully evaluate for a patella fracture, radiographs of the knee need to include an AP, lateral, sunrise, and Merchant views.

Treatment of Patella Fracture

Assessment of the patella fracture characteristics is needed to delineate whether operative fixation is indicated. Nonoperative treatment may be appropriate if the extensor mechanism is intact, articular step-off is less than 2 mm, or fracture displacement is less than 3 mm. However, the patient will not be able to flex the knee greater than 30° for 6 weeks.[8] Operative fixation is warranted if the extensor mechanism is disrupted, articular step-off is greater than 2 mm, fracture step-off is greater than 3 mm, or if one wants to expedite rehabilitation.[8] If the FSF is amenable to retrograde nailing, then one incision can be used to fix both patella and FSF. Fractures of the patella can be treated with a tension band construct with Kirschner wires and an 18-gauge wire or 4.0 mm cannulated screws with an 18-gauge wire for tension band. Biomechanically, the 4.0 mm cannulated screws with an 18-gauge wire is a stronger construct.[9] Other options are patella plating, cerclage wiring, lag screws, tension band construct with large braided suture, or partial patellectomy (if unable to capture the inferior pole or superior pole with fixation).

IPSILATERAL TIBIAL SHAFT ("FLOATING KNEE")

The combination of FSF and tibial shaft fractures (TSF) are usually due to high-energy trauma from MVA, motorcycle accidents, or pedestrian-versus-vehicle accidents.[10] The "floating knee" fracture can be various combinations ranging from intra-articular fractures of one bone with a shaft fracture of the other bone, intra-articular fractures of both bones, or shaft fractures of both bones. Additionally, vascular injuries, knee injuries, and open fractures are common with floating knee injuries and should be fully investigated.[10] Radiographs of the complete tibia with the ankle and knee joints included are needed. If intra-articular extension is suspected, then dedicated radiographs and CT scan of the involved joint are needed.

Treatment of Ipsilateral TSF

Operative planning can begin once diagnosis is confirmed with imaging. Only FSF with TSF is addressed in this article. This combination is an indication for retrograde nailing of the FSF and antegrade nailing of the TSF. Careful investigation is needed to make sure that the TSF or the FSF does not propagate into their respective articular surfaces. The appropriate approach to use depends on where the FSF and TSF are located. The most convenient approach is using a single incision distal to the patella, which one can retrograde the femur and antegrade the tibia. Gregory et al[11] reported good or excellent results in 13 of 20 patients. Of these patients, seven patients had single incisions for both fractures and had acceptable results. They also reported an average of 120° of knee range of motion (95 to 140°), with no one having more than occasional knee pain. If the TSF is a proximal fracture, then it is much more difficult to nail with the infrapatellar approach, thus consideration of doing a supra-patellar approach to the tibia and an antegrade approach to the FSF is appropriate. If the patient has a soft-tissue defect or a contaminated wound, then one can proceed with an external fixator for provisional or definitive treatment.

KNEE LIGAMENT INJURY

Ligament injuries of the knee have been associated with FSF. Szalay et al[12] stated in their research that 27% of their patients had knee ligament laxity with an isolated FSF. Dickob et al[13] examined FSF and ligament injury, and they found that 18.6% of patients had damage to at least one of the cruciate ligaments. DeCoster et al[14] reported an 11.6% ipsilateral knee ligament injury out of 163 FSF, with medial collateral ligament being the most common ligament injured followed by anterior cruciate ligament, posterior cruciate ligament, and lateral collateral ligament, respectively. Giannoudis et al[15] reported five cases of FSF with knee dislocation, which were managed by reducing all knees, placement of IMN in the femur, angiography, followed by either bracing or ex-fixation for 6 weeks. It is difficult to do a knee examination when the patient has FSF. If the diagnosis of a knee dislocation is being considered, it is imperative to do at least an ankle-brachial index on the ipsilateral leg. The literature shows to proceed with a CT angiography to rule out an injury to an artery. A complete knee examination needs to be performed under anesthesia to achieve more accurate results.

Treatment of Knee Ligament Injury

Depending on the number and severity of knee ligaments disrupted, one can treat the knee with an external brace versus an external fixator. If an artery injury is ruled out then it is best to proceed with nailing of the FSF to stabilize the extremity followed by treating the knee injury with bracing or external fixation. One can proceed with the ligament reconstruction at a later date.

ACETABULAR AND PELVIC RING FRACTURE

Acetabular and pelvis fractures with ipsilateral FSF have been termed "floating hip." Rajasekaran et al[16] reported the incidence of floating hip to be around 1 in 10,000 fractures. In their study examining pedestrian and MVA, Brainard et al[17] showed that 35 of 115 patients had an ipsilateral pelvis fracture, femur fracture, and a higher mortality rate. Müller et al[18] also stated in their study that there is a high morbidity and mortality rate with ipsilateral femur and pelvis fractures. Burd et al[19] reported between 26 to 35% injury to the sciatic nerve with a floating hip injury. It is important to do a good physical examination and obtain adequate imaging to diagnose and plan for operative intervention.

Treatment of Floating Hip injuries

According to injury patterns, the surgeon needs to determine whether to operate on the pelvis or femur first. One has to be mindful of the next surgery and where to place incisions. If one is doing a posterior approach to the acetabulum, then a Gibson approach can be considered, which will also allow access to the posterior acetabulum and access for antegrade nailing of the FSF. If antegrade-nailing incision will block the incision needed for the acetabulum or pelvis, then a retrograde approach can be used to address the FSF.

SMALL BONE FRACTURES

Fractures of small bones can go unnoticed owing to the distracting injury of FSF. It is imperative to do a secondary survey to confirm that no fractures of the small bones are missed (eg, scaphoid, metacarpals, metatarsals). Long-term sequelae may occur if these injuries are missed, including nonunion, malunion, or chronic pain.

CONCLUSION

It is important to recognize injuries associated with femoral shaft fractures in order to obtain optimal patient results. This requires a high level of suspicion,

due diligence in pursuit of radiographic images over time, and clinical investigation (ie, secondary survey, etc). When associated injuries are recognized, the treatment of the femoral shaft fracture may need to be adjusted. Along with the FSF, the associated injuries need to be treated in an optimal, timely fashion.

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